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environmental restoration project

A Department of Energy Environmental Cleanup Program

Environmental Restoration Project
Standard Operating Procedure

for:

CONTRACT GEOPHYSICAL LOGGING

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Revision Log

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Contract Geophysical Logging

1.0 PURPOSE

This Standard Operating Procedure (SOP) states the responsibilities and describes the general process for obtaining borehole logging data of acceptable quality regardless of logging system or logging contractor, to meet the site-characterization and/or subsurface-sampling requirements for a Focus Area (FA) at the ER Project and as part of a RCRA (Resource Conservation and Recovery Act) Facility Investigation (RFI).

2.0 SCOPE

This SOP is a mandatory document and shall be implemented by all ER Project participants when contract geophysical borehole logging is performed at for the ER Project.

3.0 TRAINING

3.1 All users of this SOP are trained by self-study and the training is documented in accordance with QP-2.2.

3.2 The Field Team Leader (FTL) will monitor the proper implementation of this procedure and ensure that relevant team members have completed all applicable training assignments in accordance with QP-2.2.

3.3 The FTL responsible for borehole logging within a given FA should be familiar with the following:

- identified SOPs (see Section 9.0, References)
- borehole logging technical specifications (BLTSs)
- contractor-specific logging procedures (CSLPs)

4.0 DEFINITIONS

Note: A glossary of definitions can be located on the ER Project internal homepage *http://erinternal.lanl.gov*.

4.1 *Blueline* — A general term for a hard copy of borehole logging data in the form of graphs of one or more logging parameters as a function of depth. Historically these have been blue-on-white prints on z-fold paper; although that format is becoming less common, the term blueline is still commonly used to denote hard copies of logs regardless of copy color.

4.2 *Borehole corrections* — Factors obtained from charts or algorithms to correct the logging data for any conditions that deviate from the conditions under which the system was calibrated; also known as environmental corrections. For example, if the system was calibrated in a 6-in. borehole and is being used in a 4-in. borehole, the results may require correction. Other such corrections include fluid invasion, mudcake, casing, and borehole fluid.

4.3 *Borehole logging* — The process of making remote measurements of physical, chemical, or other parameters at multiple depths in a borehole.

4.4 *Borehole Logging Technical Specifications (BLTSs)* — Documents included in the site-specific Statement of Work that define the capabilities and data quality required of prospective logging contractors.

4.5 *Calibration* — A test or tests performed against known standards with a given logging system to verify that the system is functioning properly and to provide calibration values that allow the data from the system to be used quantitatively. Standard calibrations include shop calibrations which are performed at specified time intervals and after any equipment modification or repair, and field calibrations, which are performed immediately before and after a logging run or operation (also known as pre- or postlog calibrations).

4.6 *Contractor-Specific Logging Procedures (CSLPs)* — Documents supplied by the logging contractor and approved by the University Technical Representative (UTR) or designee before the contract is awarded. The CSLPs define the detailed procedures by which a given logging system will be calibrated and operated to achieve objectives for data type and quality given in the BLTSs.

4.7 *Drilling fluid* — A liquid or gas circulated into the borehole during the drilling process to cool and lubricate the bit and carry cuttings out of the borehole.

4.8 *Field Implementation Plan* — A document package that includes guidance on drilling, sampling, and geophysical logging, as necessary, to meet the sampling requirements defined in the site-specific Statement of Work (SOW). This package is prepared by the FTL or FTL's representative and is approved by the Subsurface Technical Team.

4.9 *Fluid invasion* — The migration of drilling fluid or one or more components of the drilling fluid into the pores, fractures, and other openings of the formation near the borehole.

4.10 *Instrument drift* — A systematic change in the output of a given logging system due to causes inherent in the logging system, such as changing tool temperature or the deterioration of an electronic component.

4.11 *Log header* — One or more pages of information included with each blueline and with logging data recorded digitally on magnetic tapes or disks. The

minimum information required in the log header is specified in the BLTSs and includes such information as name and location of hole, logging services performed, and the date and time of beginning and end of the log.

4.12 *Logging run* — A single data-collecting pass with a logging tool, as it moves up or down the borehole or a portion of the borehole. A given logging operation will generally consist of a main run and one or more repeat runs with each logging tool.

4.13 *Logging tool* — A device that is run in a borehole to make borehole logging measurements.

4.14 *Logging tool stack* — Two or more logging tools attached together and run as a single unit to save time and improve the depth correlation between logs.

4.15 *Mudcake* — A layer of mud that may be deposited on the borehole wall when the drilling fluid contains mud; when the liquid component of the mud invades the formation, the solid component may be left on the borehole wall.

4.16 *Percussion gun* — A device run on a wireline to obtain samples from a borehole wall. On a single run, multiple sample tubes or hollow shells are driven into the borehole wall at various depths by explosives and retrieved along with the samples.

4.17 *Repeat run* — A logging run, which may cover only a portion of the depth range of the main logging run, used to help judge data repeatability, as a check on instrument drift, and other data quality problems. The repeat run may be performed before or after the main run and is typically 100 ft in length. In boreholes less than 150 ft in depth the repeat run may be shorter, provided sufficient salient data trace features can be observed for data quality evaluation.

4.18 *Site-Specific Health and Safety Plan (SSHASP)*—A health and safety plan that is specific to a site or ER-related field activity that has been approved by an ER health and safety representative. This document contains information specific to the project including scope of work, relevant history, descriptions of hazards by activity associated with the project site(s), and techniques for exposure mitigation (e.g., engineering controls, administrative controls, and personal protective equipment [PPE]).

4.19 *Verification* — One or more tests, generally performed before and after logging in lieu of a calibration, to ascertain whether the logging system is operating properly. The verification differs from a calibration in that it does not provide updated system-calibration values.

4.20 *Wireline* — The logging cable used to support the logging tool and carry electrical power and signals between the tool and surface instrumentation.

5.0 BACKGROUND AND PRECAUTIONS

Note: This SOP is to be used in conjunction with an approved SSHASP. Also, consult the SSHASP for information on and use of all PPE.

5.1 Overview of Borehole Logging Methods

5.1.1 Introduction

In ER applications, borehole-logging techniques are used *in situ* to determine physical, chemical, geological, and hydrological conditions in an open borehole. Certain borehole logging methods are used inside the well casing after construction. Borehole logs are used to determine formational lithologic makeup and thickness, locate water-bearing zones, and to facilitate well design. Borehole data can be used to help solve waste-cleanup problems as part of initial site characterization, during remediation, and for postremediation monitoring.

For accurate results with a given logging system, it is essential that the system be calibrated against accepted standards and monitored for any malfunction or significant drift of the system calibration. In addition, the data must be corrected for nonstandard conditions (conditions other than those encountered in the calibration).

5.1.2 Borehole Logging Techniques

A list of down-hole geophysical logs that are typically used for ER Project wells is presented in Attachment A. Borehole measurements are recorded digitally by the various electronic logging tools and presented in graphical format for interpretation as Column Lithography and Borehole Geophysical logs (refer to ER-SOP-03.02).

5.1.2.1 Contaminant Mapping Logs

Contaminant Mapping Logs provide direct information on the presence of contaminants inside or outside the borehole. Borehole-logging tools exist that can estimate concentrations of certain contaminants. Even though Contaminant Mapping Logs are not Environmental Protection Agency-approved for quantitative analysis at the present time, they can, nonetheless, be used for screening and for supplying information on contamination between the locations of physical sample points along the borehole.

5.1.2.2 Engineering Logs

This category includes all logs that are not used for contaminant mapping. Examples include caliper (borehole

diameter), induction resistivity (formation electrical resistivity), and gamma-gamma density (formation bulk density).

5.1.2.3 Borehole Samples

While not strictly logs, borehole samples can be collected by some logging contractors. Typically, these take the form of borehole fluid samples, sidewall cores, or percussion-gun samples.

5.1.3 Calibration

Accurate calibrations are necessary for the data to be used quantitatively. calibrations also play an important role in monitoring tool performance over time. The CSLPs must include a complete set of written calibration procedures for all logging equipment involved in quantitative measurements. The logging contractor is responsible for maintaining full and complete documentation for all calibrations of all tools and shall provide copies of these records to the FTL for transfer to the Records Processing Facility (see section 10.0).

5.2 Health and Safety

Potential hazards during a logging operation are associated with machinery, electrical devices, radioactive sources, weather, possible contact with contaminants, and other hazards. Some of these hazards are listed below.

5.2.1 The potential hazards of machinery operation can include:

- winch problems such as drum brake failure, having the cable jump the flange, a loss of winch power, the cable becoming “birdcaged” or tangled, and having insufficient pulling power;
- rigging problems such as the cable jumping out of the sheave or the failure of the sheave wheel, tie downs, or supports; and
- logging-tool problems such as it becoming stuck in the borehole due to a hole collapse, the cable pulling out of the cable head at the tool, cable key-seated.

5.2.2 Electrical devices can pose two types of hazards, either

- direct electrical hazards such as electrical shock and burns and electrical fires or
- indirect hazards such as the failure of the depth system or the failure of the weight system (tension).

5.2.3 Radioactive sources include:

- high-intensity isotopic or chemical gamma-ray and neutron sources used as a component in some logging tools

- pulsed-neutron sources that may be accidentally actuated

5.2.4 Weather conditions that could affect logging operations include:

- High winds increase machinery and electrical hazards.
- Rain increases electrical-shock hazard.
- Lightning is hazardous to both people and equipment.
- Exposure can impair logging equipment's efficiency and accuracy.

5.2.5 Contamination

Prior to the initial logging run and after the final logging run all equipment entering the borehole must be monitored for contamination. Site workers should be aware of logging operations at all times and read and understand both the ER Project Health and Safety Plan and the SSHASP for that work site.

5.2.6 Other potential hazards include:

- fuel fires
- carbon monoxide fumes
- problems on drilling rig that might affect the operation
- personnel problems such as inadequate training, carelessness, inattention, or impairment (due to medication, drugs, ailments, etc.)

6.0 RESPONSIBLE PERSONNEL

The following personnel are responsible for activities identified in this procedure.

6.1 Focus Area Leader

6.2 Team Leader

6.3 Quality Program Project Leader

6.4 Author

6.5 ER Project personnel

7.0 EQUIPMENT

The list of equipment required for borehole logging varies with the contractor and the specific log(s) being run. Refer to the BLTSs and CSLPs for required equipment lists.

8.0 PROCEDURE

Note: Contractors performing work under the ER Project's quality program may follow this SOP for performing borehole geophysical logging. Contractors

may use their own procedures provided that the substitute procedures meet the requirements prescribed by the ER Project Quality Management Plan, and have been approved by the ER Project's Quality Program Project Leader (QPPL) before starting the activities. The logging equipment will be operated in accordance with applicable industry standards, regulatory requirements, and this SOP.

Note: ER Project personnel may produce paper copies of this procedure printed from the controlled-document electronic file located at website http://erinternal.lanl.gov/home_links/Library_proc.htm. However, it is their responsibility to ensure that they are properly trained and are utilizing the current version of this procedure. The author may be contacted if text is unclear.

Note: Deviations from SOPs are made in accordance with QP-4.2, Standard Operating Procedure Development and documented in accordance with QP-5.7, Notebook Documentation for Environmental Restoration Technical Activities.

8.1 Pre-contract Considerations

8.1.1 Before soliciting contract geophysical logging bids, detailed BLTSs must be prepared by the UTR in consultation with the FTL to define the logging objectives. The success of the logging operation depends to a large degree on these specifications. The BLTSs must specify the following:

- type of logging system
- required logging parameters
- precision
- data accuracy and repeatability
- depth accuracy
- sample interval
- calibration schedules and requirements
- data formats and media

8.1.2 Specific, detailed procedures depend on the logging system and the logging contractor. Before the contract can be finalized, contractors must submit CSPLs for approval by the designee in consultation with the PI. The CSLPs should conform to the general procedures given in this SOP.

8.2 Pre-operation Activities

In preparing for the logging operation, the FTL is responsible for ensuring that the activities and quality control checks listed below are performed.

8.2.1 Before the arrival of the logging contractor, the FTL will:

- obtain approval for property access
- review the site-specific FGD, the BLTSs, and the SSHASP for specific information on field activities
- verify that the logging equipment meets the BLTSs
- verify that the CSLPs meet the specifications outlined in the BLTSs for each logging method to be applied

8.2.2 The FTL will have the work site cleared of all brush and minor obstructions and have the location of utilities properly staked and identified.

8.2.3 With respect to the logging equipment to be used on site, the FTL will ensure that:

- all specific logging equipment has been shop calibrated within the required time period before the logging operation as specified in the BLTSs
- all logging equipment has been shop calibrated after any repair or modification even if the equipment is not yet due for a routine shop calibration
- all calibrations were within acceptable accuracy tolerances as defined in the BLTSs
- all logging equipment—including cable, cable head, and logging tool—has been decontaminated before use

8.2.4 The FTL will coordinate with ESH-12 to ensure that proper documentation is provided by the contractor for all radioactive sources that will be brought onto Laboratory property for geophysical logging. Documents may include licenses, written documentation of the contractors radiation safety program, training certificates, and routine equipment and personnel radiation monitoring results.

8.3 Borehole Geophysical Logging Activities

8.3.1 All logging operations are to be carried out as specified in the CSLPs.

8.3.2 FTL will ensure that the appropriate personnel are present to monitor the logging equipment as it emerges from the borehole or before it leaves the work site for contamination. (Refer to the SOPs in Section 7.0, References, for guidance.

8.3.3 The FTL will ensure that each logging tool is field calibrated or field verified as required in the BLTSs. A field calibration or verification is usually required both immediately before and immediately after a logging run or runs with a given logging tool. Ensure that this process

is properly carried out according to the CSLPs and that the readings are within acceptable limits as defined in the BLTSs.

8.3.4 The FTL will ensure that the logging equipment is decontaminated between sampling events as specified in ER-SOP-01.08.

8.3.5 If borehole samples (e.g., water, sidewall-core, or percussion-gun samples) have been collected by the logging contractor the FTL will ensure that borehole materials are field screened for hazardous and radioactive constituents.

8.3.6 If borehole materials prove hazardous, the FTL will take appropriate action for handling. Handle hazardous borehole materials according to procedures established in SOPs in the SOP Manual, Section 1.0.

8.3.7 The FTL will ensure that a Chain-of-Custody/Request for Analysis Form (Attachment C in ER-SOP-01.04) is completed for all analytical samples. The FTL will accompany the samples to the Sample Management Office (SMO).

8.3.8 The FTL will monitor the collection and containerizing of all waste materials and decontamination solutions for proper disposal, as described in ER-SOP-01.06.

8.4 Postoperation Activities

8.4.1 The FTL will verify that all tools were calibrated and that the logging runs covered the correct depth intervals of the borehole that were requested.

8.4.2 The FTL will ensure that log headers are correct and complete and meet the specifications given in the BLTSs. The FTL will then sign and date the form as a witness.

8.4.3 The FTL will obtain copies of field data in hard-copy form and digital form (magnetic tapes, CD-ROM or magnetic disk), as specified in the BLTSs. These field copies are an important part of the data quality record even though re-processed data may be submitted by the logging contractor at a later date.

8.4.4 The FTL will ensure that all borehole logging equipment is accounted for, decontaminated, and ready for transport.

8.4.5 The FTL will ensure that the site is restored to pre-logging operation conditions or as specified in the FGD. The FTL will also ensure that the borehole is capped and/or marked as required.

8.5 During the performance of work, ER Project personnel shall identify, document and submit lessons learned in accordance with QP-3.2, Lessons

Learned. This QP can be located at website: http://erinternal.lanl.gov/home_links/Library_proc.htm.

9.0 REFERENCES

The following documents have been cited within this procedure:

Borehole Logging Technical Specifications

Contractor-Specific Logging Procedures

QP-2.2, Personnel Orientation and Training

QP-3.2, Lessons Learned

QP-4.2, Standard Operating Procedure Development

QP-4.3, Records Management

QP-5.7, Notebook Documentation for Environmental Restoration Technical Activities

ER-SOP-01.04, Sample Control and Field Documentation

ER-SOP-01.06, Management of Environmental Restoration Project Wastes

ER-SOP-01.08, Field Decontamination of Drilling and Sampling Equipment

ER-SOPs in the SOP Manual, Section 1.0, General Instructions

ER-SOP-03.02, General Surface Geophysics

10.0 RECORDS

The FTL is responsible for submitting the following records (processed in accordance with QP-4.3, Records Management) to the Records Processing Facility.

10.1 Hard copies of logging data ("bluelines") with completed headers, signed by logging-contractor representative and the FTL, or other approved witness, as specified in the BLTSs.

10.2 Digital data on magnetic tape or as otherwise specified in the BLTSs.

10.3 A Borehole Log Quality Report (BLQR) for each logging service run, as specified in the BLTSs. Completing the BLQR is the responsibility of the FTL.

10.4 Calibration records as specified in the BLTSs.

10.5 Completed Chain-of-Custody/Request for Analysis Form (Attachment C in ER-SOP-01.04) for any borehole samples collected.

11.0 ATTACHMENTS

ER project personnel may use documentation formats different from those attached in this SOP—provided the substitute forms include the information required in the official forms.

Attachment A: Typical Wire-Line Geophysical Logging Tools (1 page)

Attachment B: Borehole Status Form (1 page) located at http://erinternal.lanl.gov/Quality/forms.htm.

Attachment C: Log Header Form (1 page) located at http://erinternal.lanl.gov/Quality/forms.htm.

Using a token card, click here to record "self-study" training to this procedure.

If you do not possess a token card or encounter problems, contact the RRES-ECR training specialist.

Typical Wire-Line Geophysical Logging Tools

Cased Hole	*Cased Hole*	*Open Hole*	*Uncased Hole*
Array Induction imager Tool (AIT)		X	Measure open hole formation conductivity with multiple depths of investigation at varied vertical resolution.
Triple LithoDensity tool (TLD)	X	X	Evaluation of formation porosity where grain density can be estimated.
Fullbore Formation Micro Imager (FMI) (saturated zones only)		X	Provides detailed images of clasts and sedimentary structures of variable resistivity; can determine strike and dip of bedding.
Combinable Magnetic Resonance tool (CMR)		X	Provides information on water content and relative abundance of hydrous minerals and capillary-bound versus mobile water.
Natural Gamma Tool	X	X	Used to distinguish lithologies by their gross gamma signature; also used to calibrate depth of other geophysical tool readings.
Natural Gamma Ray Spectrometry tool (NGS; also called the spectral gamma tool)	X	X	Used to distinguish lithologies where formations vary in relative and overall concentrations of potassium, thorium and/or uranium.
Epithermal Compensated Neutron Log (CNL)	X	X	Measures moisture content in unsaturated conditions and porosity in saturated conditions.
Caliper	X	X	Measures deviations/variation in borehole diameter.
Mechanical Sidewall Coring Tool (MSCT)		X	Designed to retrieve multiple, high quality sidewall cores in hard formations for chemical analysis or hydraulic-property testing.
Elemental Capture Spectrometer (ECS)	X	X	Determines formation lithology from bulk geochemistry; primary use in determination of elemental concentrations of Si, Ca, Fe, Ti and Gd.

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BOREHOLE STATUS FORM

To be filled out by drilling engineer or site geologist

Logging Date: ____/____/__ Borehole / Well Name: _____

Contractor: _____

Well Status: ☐ Open Hole ☐ Completed ☐ Other _____

Number of Concentric Casing(s): _____ Current Borehole Depth_____

Casing Top Depth						
Casing Bottom Depth						
Casing Inside Diameter						
Casing Wall Thickness						
Casing Type/Material						
Bit Size						
From						
TO						
Cement Plugs						
From						
TO						

Type of Fluid in Hole: _____ Fluid Level: _____ft.

Casing Collars: ☐ Yes

Average Spacing: _____ft.

Shoes: ☐ Yes

Other Materials in Hole:

_____From_____To_____ft.

_____From_____To_____ft.

_____From_____To_____ft.

Reason for running log:

Comments:

Form Completed By: _____ **LANL Observer:** _____

QA Reviewer: _____

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LOG HEADER FORM

Fill out one form for each logging run

Logging Date: __/____/__ Borehole / Well Name: _____

Contractor: _____ Operator: _____

Run Number: _____ Logging Vehicle Number: _____ ☐ LANL Logging Trailer

Log Type:

☐ Gamma Ray
☐ Gamma-Gamma Density
☐ Resistivity

☐ Temperature
☐ Fluid Flow
☐ Induction

☐ Hole Deviation
☐ Acoustic (Sonic)
☐ Spontaneous Potential

☐ Neutron
Calibration Matrix:
☐ *Dolomite*
☐ *Limestone*
☐ *Sandstone*

☐ Borehole Video
☐ Caliper
*Number of Arms*_____

☐ Other _____
_____

Electronic File Name: _____ Format: _____
Null Value (*If Applicable*): _____
Start Time: _____ End Time: _____
Measuring Point Description: ☐ GL (Ground Level) *Default to Ground Level when suitable*
☐ Other _____
Measuring Point Relative to Ground Level: ft
Log Run Through: ☐ Casing ☐ Annular Space ☐ Tremie ☐ Open Hole
Bottom Log Depth: ft Top Log Depth: ft
Uniform Logging Speed? ☐ No Logging depth increment: _____
Quality of Log: ☐ Good ☐ Fair ☐ Poor
Quality Comment (*Required for Fair or Poor*):

Calibration Note:

Logger Remarks:

Form Completed by: **LANL Observer:** _____
QA Reviewer: _____

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